



***TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.***

# **Autonomous Vehicles Panel**

## **2011 Pacific Operations Science & Technology Conference**

Dr. Grace Bochenek

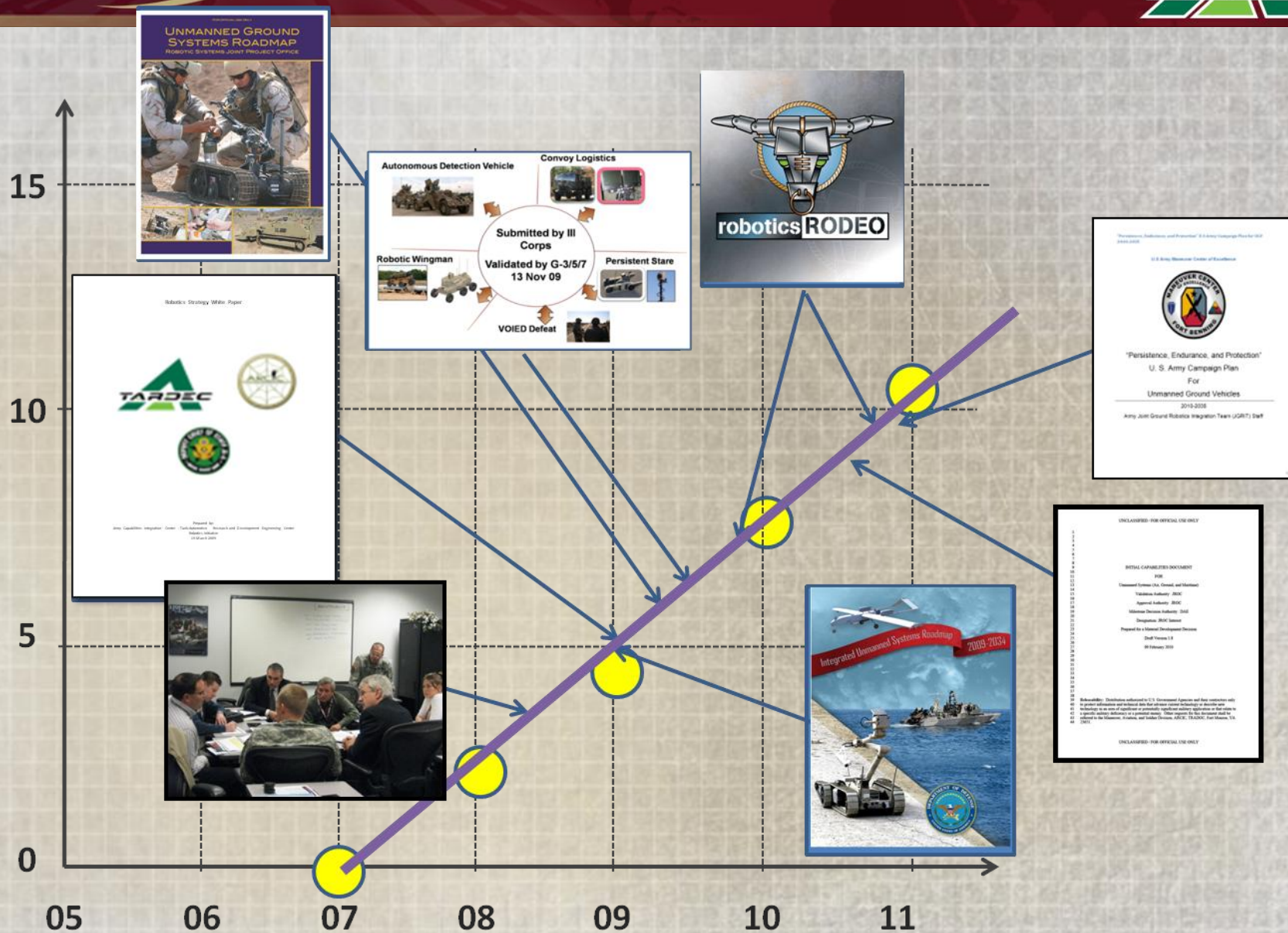
Director, U.S. Army RDECOM-TARDEC

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| Report Documentation Page  |                                    |  | Form Approved<br>OMB No. 0704-0188       |                                  |                                 |
|--|------------------------------------|--|--|----------------------------------|---------------------------------|
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| 1. REPORT DATE<br><b>16 MAR 2011</b>   | 2. REPORT TYPE<br><b>N/A</b>       | 3. DATES COVERED<br><b>-</b>                                   |  |                                  |                                 |
| 4. TITLE AND SUBTITLE<br><b>Autonomous Vehicle Panel</b>   |                                    | 5a. CONTRACT NUMBER  |  |                                  |                                 |
|  |                                    | 5b. GRANT NUMBER   |  |                                  |                                 |
|  |                                    | 5c. PROGRAM ELEMENT NUMBER                                     |  |                                  |                                 |
| 6. AUTHOR(S)<br><b>Dr. Grace Bochenek</b>  |                                    | 5d. PROJECT NUMBER   |  |                                  |                                 |
|  |                                    | 5e. TASK NUMBER  |  |                                  |                                 |
|  |                                    | 5f. WORK UNIT NUMBER   |  |                                  |                                 |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br><b>US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000, USA</b>  |                                    | 8. PERFORMING ORGANIZATION REPORT NUMBER<br><b>21618</b>       |  |                                  |                                 |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)<br><b>US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000, USA</b>   |                                    | 10. SPONSOR/MONITOR'S ACRONYM(S)<br><b>TACOM/TARDEC/RDECOM</b> |  |                                  |                                 |
|  |                                    | 11. SPONSOR/MONITOR'S REPORT NUMBER(S)<br><b>21618</b>         |  |                                  |                                 |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT<br><b>Approved for public release, distribution unlimited</b>  |                                    |  |  |                                  |                                 |
| 13. SUPPLEMENTARY NOTES<br><b>Presented at the 2011 Pacific Operations Science &amp; Technology Conference, 14-17 March 2011, Hawaii, USA, The original document contains color images.</b>  |                                    |  |  |                                  |                                 |
| 14. ABSTRACT   |                                    |  |  |                                  |                                 |
| 15. SUBJECT TERMS  |                                    |  |  |                                  |                                 |
| 16. SECURITY CLASSIFICATION OF:  |                                    |  | 17. LIMITATION OF ABSTRACT<br><b>SAR</b> | 18. NUMBER OF PAGES<br><b>13</b> | 19a. NAME OF RESPONSIBLE PERSON |
| a. REPORT<br><b>unclassified</b>   | b. ABSTRACT<br><b>unclassified</b> | c. THIS PAGE<br><b>unclassified</b>                            |  |                                  |                                 |














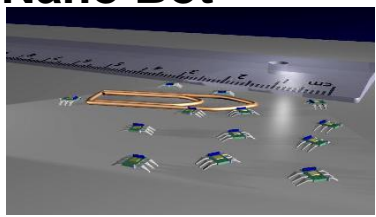



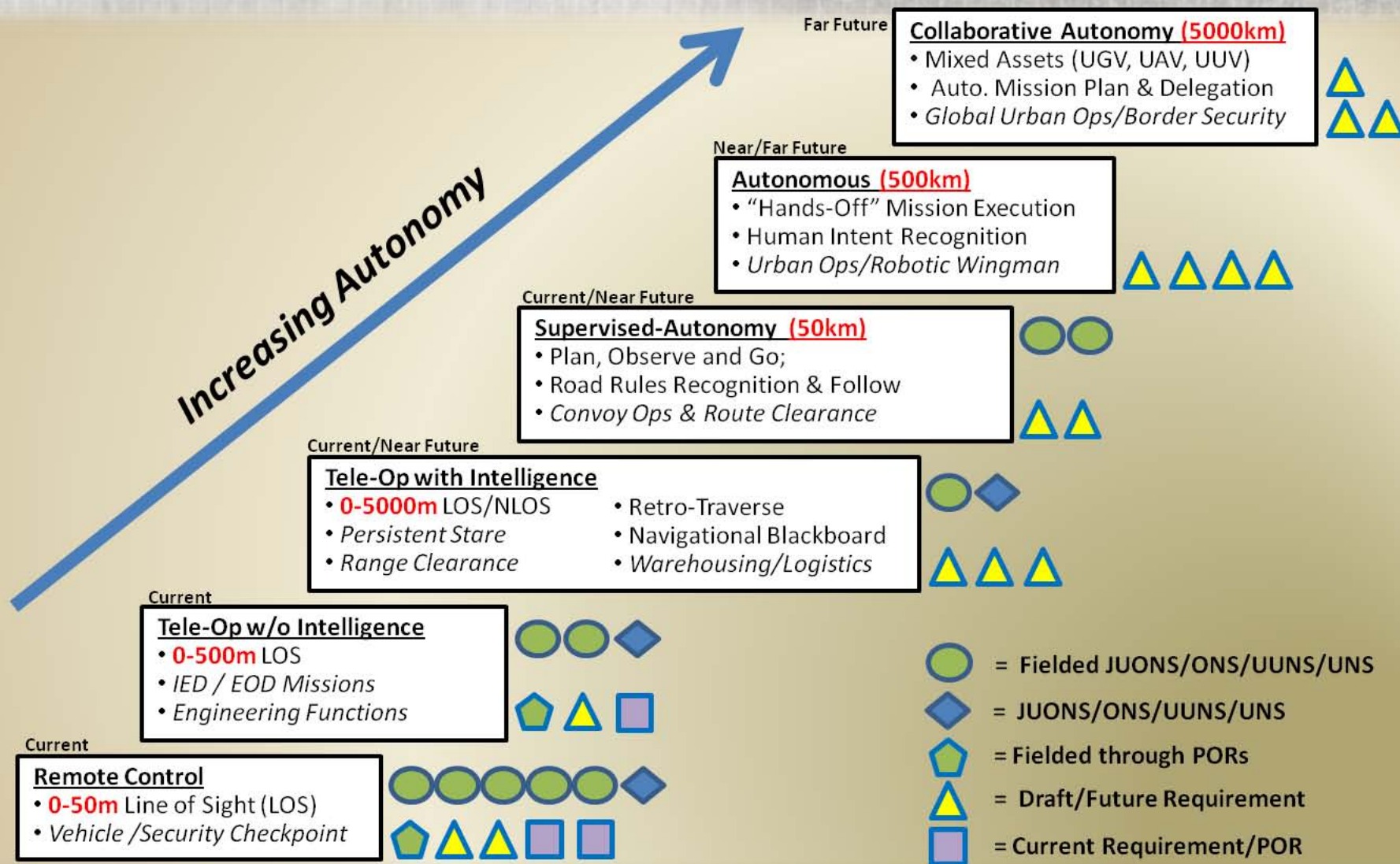
# The Road to Requirements





# Ground Robotics Capability Sets (photos are notional representations)

| Soldier Transportable   | Vehicle Transportable   | Self Transportable   | Appliqué  |
|---|---|--|---|
| <div>Crew Served Bot</div> <div></div>   | <div>Mounted or Towed</div> <div><div>Man Transportable Robot System (MTRS) POR</div><div></div></div>           | <div>Soldier Follower IBCT</div> <div><div></div><div>Squad Multi-purpose Equipment Transport (SMET) CDD</div></div> | <div>Remote Operation</div> <div><div></div><div>Husky Mounted Detection System (HMDS) POR</div></div>         |
| <div>Small Bot</div> <div><div>Small Unmanned Ground Vehicle (SUGV) CDD</div><div></div></div> | <div>Armed</div> <div><div></div><div>M160 Light Flail POR</div></div>   | <div>Medium Wingman SBCT</div> <div><div></div><div>Multi-Mission Unmanned Ground Vehicle (MM-UGV) CDD</div></div>   | <div>Supervised Autonomy</div> <div><div></div><div>Autonomous Mobility Appliqué System (AMAS) CDD</div></div> |
| <div>Micro Bot</div> <div><div></div><div>CPD To be released</div></div>                       | <div>Humanoid</div> <div><div></div></div>  | <div>Heavy Wingman HBCT</div> <div></div>   | <div>Full Autonomy</div> <div></div>  |
| <div>Nano Bot</div> <div></div>   | <div>Squad Member</div> <div><div>Battlefield Extraction Assist Robot (BEAR) Initiative</div><div></div></div> | <div>Exoskeleton</div> <div><div>Exoskeleton (XOS) CDD</div><div></div></div>                                     |   |







# Ongoing Robotics Efforts

## How the Army will keep it's Technology Edge



### MAST CTA

*Basic Research for Micro-systems*  
BAE, JPL, Michigan, Penn, Maryland, GA Tech,  
UC Berkeley, MIT



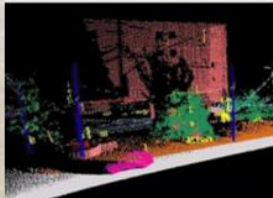
- Autonomous operation of a collaborative ensemble of multi-functional, mobile micro-systems
- Micro-mechanics
- Micro-electronics
- Processing for autonomy
- Integration of multi-functional component technologies



Near-term Quad-rotor

### Robotics CTA

*Fundamental Robotics Research*  
GDRS, CMU, UPENN, Qinetiq, UCF, Boston  
Dynamics, FAMU



- Fundamental technology to enable teaming of "intelligent" unmanned systems with soldiers
- Perception
- Planning, learning, & adaptation to dynamic, unknown environments
- Human-robot interaction
- Dexterous manipulation & unique mobility



CAMS JCTD vehicle

### MAGIC

*International Robotics Challenge*  
U of MI, U of PA, Robotics Research



- Harvest "Best-in-class" technology for teaming of autonomous SUGVs
- Many robots/few operators
- Autonomous mobility
- Planning for dynamic environments
- Minimize required soldier interaction
- Tactical behaviors
- Heterogeneous teaming



Team RASR's modified TALONS

### RDP's

*Research & Demonstration Projects Conducted by RDECOM & other Army Organizations*



- Focused Research and Advanced Development programs directed at maturation and demonstration of new technical capabilities
- Safe Operations of Unmanned Systems in Complex Environments (SOURCE)
- Improved Mobility and Operational Performance through Autonomous Technologies (IMOPAT)



TARDEC APD Testbed Platform

### Robotics Rodeo

*Industry S&T Market-Survey*  
iRobot, Oshkosh, John Deere



- Open solicitation for developers to bring systems for assessment by both soldiers and technologists
- Structured assessments in relevant environments and exposition of broad swath of available technology
- Opportunity to include new & novel technology into Army Acquisition



GUSS vehicle



## Some Challenges:

### Cultural

- An unwillingness to reduce force structure.
- Trust and confidence issues related to autonomous behaviors (safety)
- Appreciation of the potential return on a robotic investment.

### Moral

- Responsibilities associated with the Unmanned application of force

### Social

- The incurious nature (lack of curiosity in a machine).
- Lack of comfort for people to operate in close proximity to machines.

Robotics are enablers and catching on but, mainly as force multipliers – Not yet replacing force structure

- Move beyond ONS/JUONS capability gaps
- Develop a Robotic Environment (Test Bed or Base Ops)
- Leverage modeling and simulation for comprehensive DOTMLPF impact
- Conduct Independent Robotics Efficiencies Study to:
  - 1) Determine return on investment for tasks robotics could perform (like robotic convoying)
  - 2) Confirm that at various places along Bloom's taxonomy or some combination of dull, dirty, or dangerous tasks, we can replace humans.
  - 3) Determine personnel life-cycle cost savings
  - 4) Expose the user and the military community to semi-autonomous robotics through test bed, base and installations operations



# MAGIC 2010 Partners

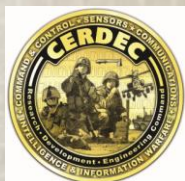


*"The U.S. and Australian Departments of Defense jointly sponsored MAGIC 2010 to attract innovative proposals from worldwide research organizations to develop heterogeneous teams of ground robots that operate autonomously with a minimum number of users that can be deployed effectively in military operations and civilian emergency situations."*

- taken from MAGIC2010 Website



Australian Government  
Department of Defence  
Defence Science and  
Technology Organisation



NIST



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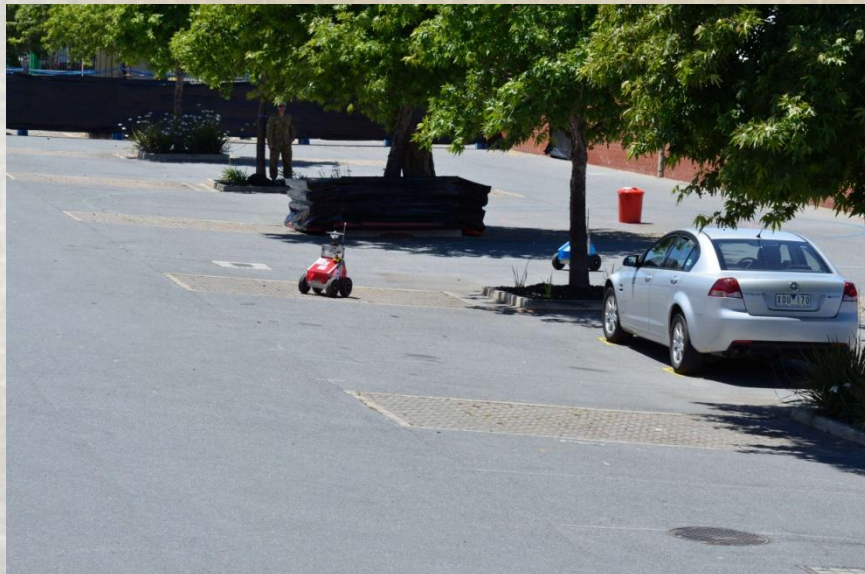




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- 1. Flip the ratio of controllers to robots, i.e. less operators; more robots**
- 2. Imbed individual and group 'behaviors' in teams of heterogeneous mobile platforms**
- 3. Coordinate all assets in a bandwidth-limited urban environment**
- 4. Show dynamic allocation and re-planning of robot resources under 'loss of robot' scenarios**



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# Tasks



Mapping



Identifying



Neutralizing

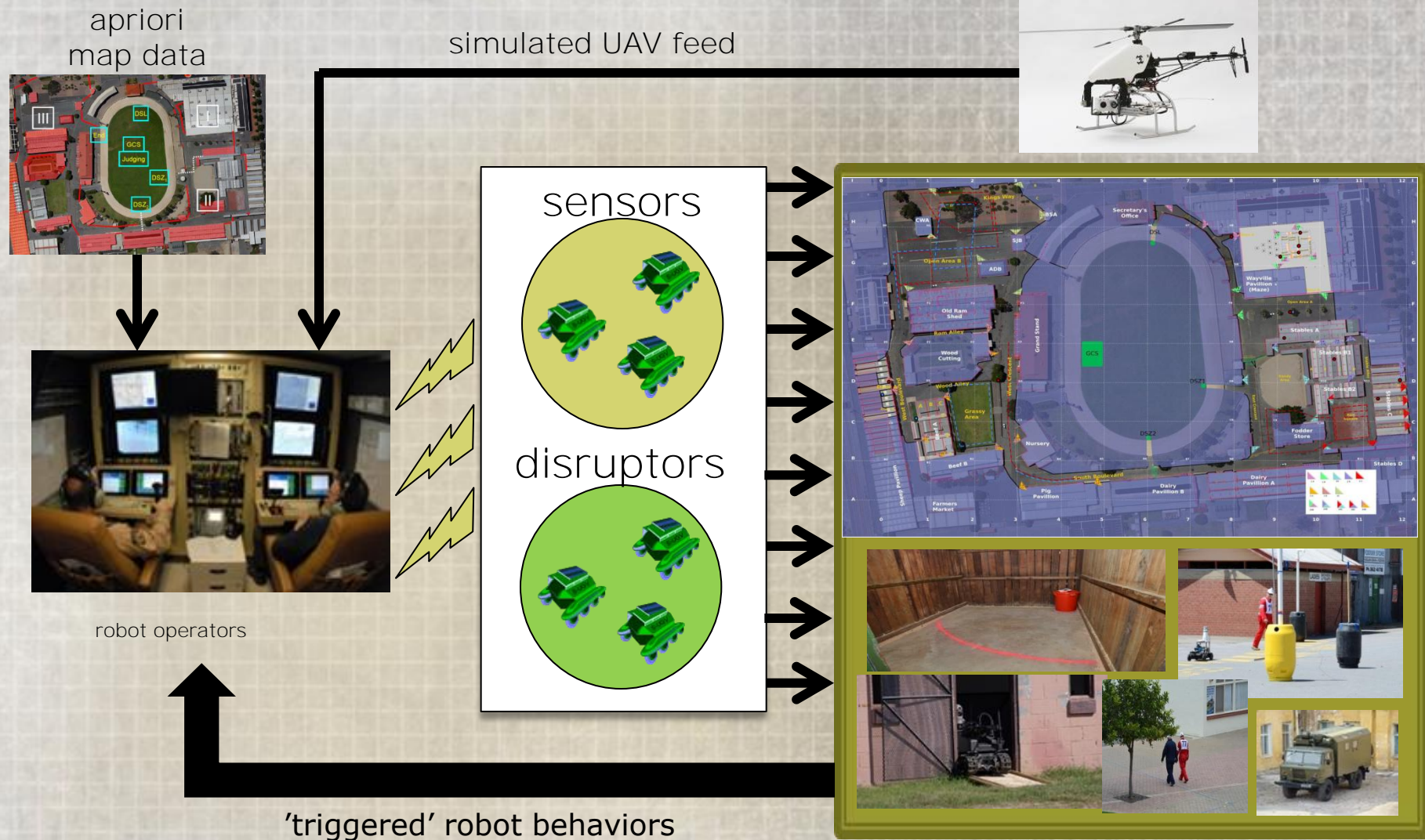


$\leq 2$  Operators  
 $\geq 3$  Robots



3.5 Hours to Complete







## **"Cappadocia" – Ankara, Turkey**

- Comprising ASELSAN (Turkish military electronics company) with Bilkent University, Bogazici University, Middle East Technical University from Turkey, and Ohio State University (Control & Intelligent Transportation Research Lab) of the USA.

## **"Magician" – Perth, Australia**

- University of Western Australia (Robotics and Automation Laboratory, Adaptive Systems Research Group), Flinders University (Artificial Intelligence and Intelligent Systems Laboratories), Edith Cowan University (Artificial Intelligence and Software Engineering Cluster), Thales Australia (D3S&A, Naval Division), ILLIARC Pty Ltd.

## **"RASR" – Gaithersburg, MD**

- Reconnaissance and Autonomy for Small Robots Team - USA (Lead: Robotic Research, LLC; with Industry Partners: General Dynamics Robotic Systems, QinetiQ-NA, Del Services, Cedar Creek Defense, Carnegie Mellon Robotics Institute, Embry-Riddle Aeronautical University, University of Michigan).

## **"Team Michigan" – Ann Arbor, MI**

- Comprising Soar-Tech with research support from the University of Michigan.

## **"University of Pennsylvania" – Philadelphia, PA**

- BAE Systems as auxiliary team members.

**1st Place/\$750K - Team Michigan**

**2nd Place/\$250K - University of Pennsylvania**

**3rd Place/\$100K - RASR**



The winners of the competition were announced at the Land Warfare Conference in Brisbane, Australia on 17 November 2010

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## 3 Major Innovations



- Low cost omni-directional camera and software for 360 SA
  - UPENN



- Stripped down TALON IV platform with RSTA head and weighing under 40 Kg
  - RASR

- Michigan 3D bar-code for localization
  - Team Michigan



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